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Estimation of recycling ages of subducted oceanic crusts: constraint from Pb and Nd isotopic composition of OIB

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Recycling of crustal material into the mantle is considered to play a key role for the chemical evolution of the Earth, producing heterogeneity in the mantle (e.g., Hofmann and White, 1982; Zindler and Hart, 1986; Weaver, 1991; Stracke et al., 2005; Stracke et al., 2012). Essential information on the recycling process may be residence time of crustal material in the mantle (recycling age) which is typically shown with timescale from formation of oceanic crust to remelting of the oceanic crust in an uprising plume via subduction and storage at deepest mantle. As the recycling ages can directly constrain timescale of mantle convection, considerable research effort has been made (Andersen et al., 2015; Christensen and Hofmann, 1994; Elliott et al., 1999; Kellogg et al., 2007; Rudge, 2006; Sobolev et al. 2011; Xie and Tackley, 2004). However, definitive estimate of the recycling age has remained unclear.

We estimated recycling ages of oceanic crusts by combining Pb and Nd isotopic composition of OIB for selected hotspots, those are, Ascension, Azores, Macdonald (Cook-Austral islands), Raivavae (Cook-Austral islands) and St. Helena. These hotspots were chosen because OIB derived from these hotspots showed HIMU or FOZO isotopic signature which might imply that their source areas could be comprised of recycled oceanic crust and DMM without continental crustal materials (e.g., Chauvel et al., 1992; Shimoda and Kogiso, 2019; Stracke, 2012; Stracke et al., 2005). The estimated recycling ages for HIMU sources are 1.48-1.71 Ga for Macdonald, 1.82-2.02 Ga for St. Helena. The difference in recycling ages of these HIMU hotspots, about 0.3 Gyr, consistently explained their geochemical differences, i.e., the St. Helena had higher $^{207}Pb/^{206}Pb$ and lower $^{3}He/^{4}He$. The estimated recycling ages of FOZO sources were 1.23-2.20 Ga for Ascension, 1.11-2.59 Ga for Azores and 0.88-1.62 Ga for Raivavae, showing wide variation in recycling ages. These results suggested that time-scale of material cycle in the Earth was not uniform and varied widely at least from 0.9 to 2.6 billion years.